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Feature Vector Creation Using Hierarchical Data Structure for Spatial Domain Image Retrieval

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Abstract

Building efficient Image Features with optimal dimension and high discriminative power is important in processing the digital information hidden inside the images. Image Retrieval systems use the feature vectors to retrieve similar images based on feature vector similarity. Image Feature Vector generation is important step in CBIR. Most of the CBIR use Linear Data structure for Feature Vector. In this paper the Hierarchical data Structure: Binary Tree is used for Feature vector creation in Image Retrieval Systems. Images in Spatial Domain are considered for Feature Vector Generation. Low-level Feature: Color Descriptors are used as Image Contents, to represents the image in feature vector form. Performance of the image retrieval is tested for Color Images. It has been observed that, along with the Dimensionally reduction, the proposed approach of Feature Vector generation, improves the discriminative power of Feature Vector. For RGB colorspaces the cascaded statistical features, when stores in hierarchical data structure, this provides the facility to perform the calculations in parallel manner also capable to keep discriminative power comparable w.r.t size of feature vector.

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Keywords: Color Descriptors;Hierarchical Data Strucrure; Image retrieval, Spatial Domain

1. Introduction

In the era of Information and Communication effective use of digital information is essential. This digital information is generated with high velocity and of huge variety and with different forms. It is also voluminous information been produced with greatest speed. Challenge here is to make the such digital information useful to

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solve diverse real-life problems. This digital information is available in many forms, ranging from simple text to complex charts/graphs. Various real-life problem faces need of digital information such as Agriculture, Medicine, Sports, Education, Art, Economics, Politics, Pharmaceutical etc. Digital information available in different form needs different type of processing approach. Text information available from many information sources can be processed using different text features, corpus matching, term frequency-inverse document frequency, topic modelling approaches etc. In text processing Text is considered as feature of that information. Text features are focused for text information processing. Digital Information is also available in Image form. Image information id useful in many applications like forensic, agriculture, art-design, medical, social media etc. Image Information processing is little complex than the text processing as there are no direct features available for processing of this information. So, feature engineering in Image processing is important and crucial step.

Building efficient Image Features with optimal dimension and high discriminative power is important in processing the digital information hidden inside the images. Content based Image Retrieval systems these feature vectors to retrieve similar images based on feature vector similarity [1][2][12][14]. Image Feature Vector generation is important step in CBIR.

1.1. Content Based Image Retrieval

Content based image retrieval systems helps to similar images based on their content similarity. In turn these systems are helpful in information retrieval from images. Required information need to be inputted in image format as a query, and CBIR returns all similar images of that query[11][16]. As shown in Fig. 1 Content based Images take input in terms of Images, so these systems are also called as query by example. Contents of the images are important and retrieved as image feature vector. These feature vectors are used for finding similar image from database.

Image Corpus is stored as collection of feature vectors of images. Each Feature Vector represents a unique image, created using a uniform feature engineering approach. Image, when taken as input to CBIR system, converted in feature vector by following same feature engineering approach, which has been considered for corpus

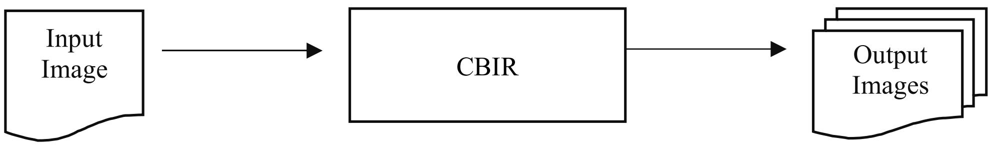

Fig. 1 CBIR System

1.2. Image Representation Using Features

All Information in the Images are represented in terms of Image Features. Each image feature represents a unique image, which is are created using Image Contents. Image contents are Image characteristics those are used to synthesize image information. Image Features are divided broadly in two types: Low level features and High-Level Feature.[19][20] Low Level Features usually use very compact knowledge about the image contents. Low Level Feature Processing methods often includes image compression, pre-processing methods for noise filtering, edge extraction and image sharpening. Low Level features are extracted using low level image contents such as Colour, Texture and Shape. High Level features are extracted using High Level(superficial) image contents such as Objects in the Image, of which low level features are core part.

1.3. Low Level Image Feature Extraction

Most low-level feature retrieval and processing methods are being used from decades. Recent research is trying to find more efficient and more general algorithms for low level feature retrieval and processing and to implement them which enables parallel processing of such feature vectors to ease the enormous computational loads of operations conducted on image data sets.

2. Spatial Domain Feature extraction

2.1. Low-Level Features: Color Descriptor

In Literature[1-6][18][19][20], various methods for low level feature: color is discussed. Many attempts were made towards the improvisation of the image retrieval performance, improvisation of discriminative power of feature vector, dimensionality reduction of feature vector. The color histogram of an image is a compelling feature. As a global property of color distribution, color histograms are generally invariant to translation and perpendicular rotations. They can also sustain modest alterations of viewing angle, changes in scale, and occlusion [17]. Their versatility may also be extended to include scaling invariance through the means of normalization [18]. However, color histograms are intolerant to the changes of illumination. Various Colorspaces are like HSV, RGB, YIQ, YCbCr are discussed in Table 1. Different colorspaces are used for different Image sources. To make Image Feature Representations, more generic, different colorspaces are used for building the feature vectors.

Table 1. Colorspaces and Discussion

Colorspaces	Description
HSV	Nonstandard Colorspace Hue, Saturation and Value(brightness) Used by Artist, Computer Graphics
YCbCr	Transmission of Luma and Croma Component
RGB	Use additive color mix Value of Particular color is expressed as vector of three elements-i.e intensities of three primary colors Used in Color TV, Storage /Processing /Coding
YIQ	Use additive color mix. Y Component describe intensity and I,Q represent color YIQ colorspaces is useful as Y components provides all that is necessary for monochrome display.

2.2. Feature Vector Creation using Hierarchical Data Structure

Image Content descriptors are basically retrieved using statistical measures like Mean, Standard Deviation, Kurtosis and Skewness. Statistical Measures are summarized values, which are helpful to capture important information from images. But when capture at single level, as these are only summaries, may lead to degrade the discriminative power which is required to identify similar and dissimilar images.

To overcome this issue, the multilevel statistical measures are extracted and used effectively for feature vector generation. To keep organize this data for feature vector we used hierarchical data structure: tree, which support multilevel data storage and retrieval. In proposed Feature Vector Generation methods, hierarchical data structure: Tree effectively used to store multilevel statistical measures captures from images

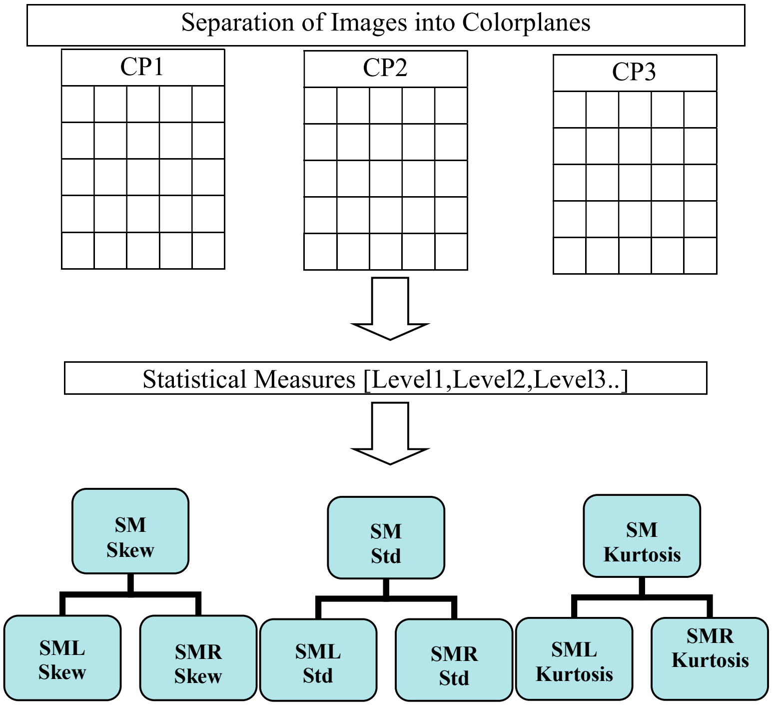

Fig. 2: Hierarchical Data Structure for Feature Vector on Spatial Domain Images

As shown in Fig.2, Tree Data Structure is used for Feature Vector Creation on Spatial Domain Color Images.
Here,
SM= Statistical Measure, SM
CP=Colorplanes
SML=Statistical measure at Left Node
SML=Statistical measure at Right Node

Statistical Measures are calculates level-wise in cascades manner. Binary Tree is effectively used for organization of Level wise calculations.Table 2 Shows Sample Feature Vectors , with FV Size and Dimensionality Reduction. For N level tree the dimensionality of feature vector is 2n -1, where n is the Level of Tree.

Table 2. Feature Vectors and Dimensionality Reduction

FV Name	FV Size	FV Reduction
F_ C Px_ STD for x=1,2,3	2^n-1	128*128 ➔2^n -1
F_C Px_ Kurtosis for x=1,2,3	2^n-1	128*128 ➔2^n -1
F_ C Px_ Mean for x=1,2,3	2^n-1	128*128 ➔2^n -1
F_C Px_ Skew for x=1,2,3	2^n-1	128*128 ➔2^n -1
F_C Pall	{2n-1 } *3	128*128 ➔{2^n -1} *3

Discriminative Power of these feature vector is good as it holds multilevel statistical measures calculated on Image. Tree level can grow upto n=5, or growth will be terminated when parent and child node of the tree hold same data or no of samples for further calculation is less than 70.

3. Image Database Creation

For Offline CBIR, two data storage are required, one is to store for all calculated feature vectors, another is to store the actual image data. Feature vectors are calculated offline and stored in database. For online CBIR, Feature vectors for input image and database images are calculated online, and results of Image retrieval is display based on similarity of feature vectors. Online CBIR required less data storage but high computing power. To process Online CBIR, the requirement is parallel execution of Task of CBIR like FV generation, Similarity Checking. With hierarchical data structure for FV, it supports parallel execution of FV creation task.

To check the performance of the system. 1000 image data is considered from WANG image database. Performance is analysed for different feature vectors and colorspaces. 1000 Images of 10 different classes are tested for performance measurement.10 classes of images with 100 images of each class, are considered. 4 Feature vectors are created for each Image. Image retrieval is tested for each.

4. Performance Measurement

Performance of the system is analysed using the Precision Measure of Retrieval. As shown in Eq, 1 precision Measure is used to check the no.of images retrieved out of total no. of retrieved Image.

$$\text{Precision} = \frac{x = \text{no of Images correctly retrieved}}{y = \text{Total no of retrieved images}} \quad (1)$$

Euclidian Distance is used to check the similarity of Feature Vectors. For testing 10 random images are selected from image database and submitted for performance evaluation.

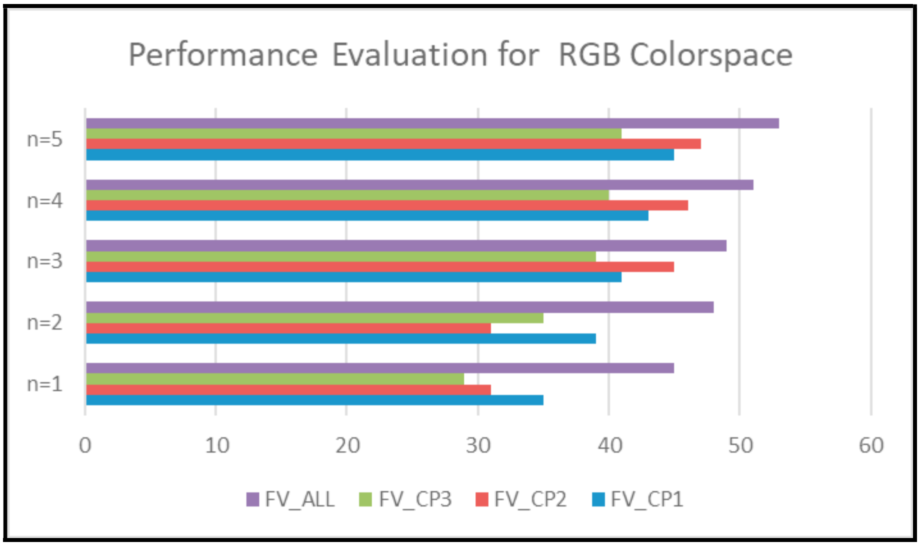

Fig. 3 Performance of Image Retrieval for Different Tree Levels and Feature Vectors for RGB colorspaces

As shown in Fig, 3, Precision Graph comparing Feature vector created using RGB colorspaces and with different levels of tree used for various feature vectors. All feature vectors are evaluated separately. It is observed that, as we use multiple levels of tree, we are getting feature vector with increased discriminative power. Retrieval rate is increased as FV size if increased.

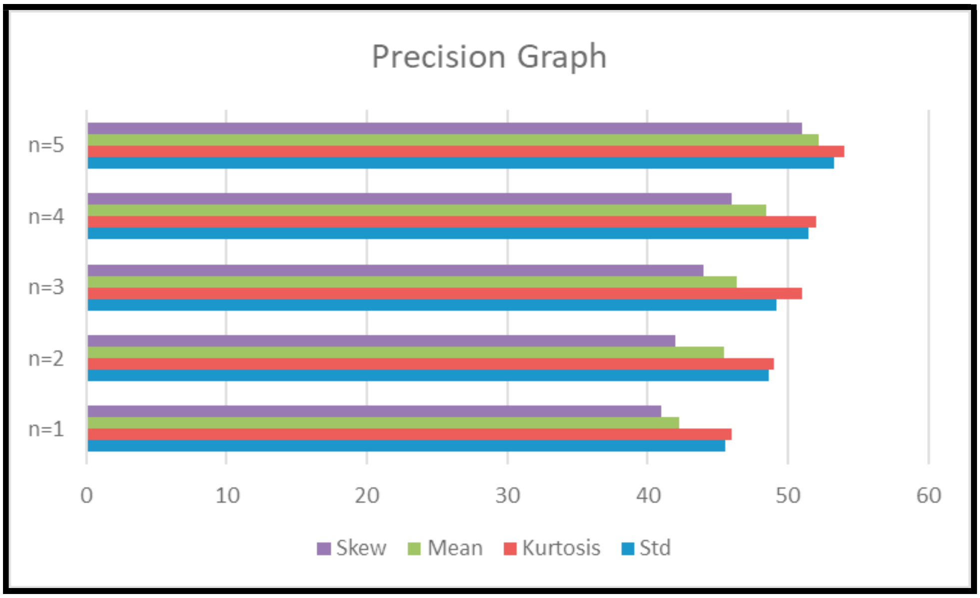

Fig. 4 Performance of Image Retrieval for Different Feature Vectors based on Statistical Measures for RGB colorspaces for FV_ALL

As shown in Fig, 4, Precision Graph comparing Feature vector created using RGB colorspaces with FV_ALL and with different statistical measures used for various feature vectors. All feature vectors are evaluated separately. It is observed that, Standard Deviation and Kurtosis provide better retrieval performance as compared to Skew and Mean.

5. Conclusion

Targeting towards feature vector size reduction, statistical measures are proved as best tool for image representations as these measures provide essential values, which optimally represent Image in Feature Vectors. But with these few set of values there is always harming to reduce the discriminative prove of feature vector. Reduction of discriminative power leads to reduction of retrieval rate. To handle this, an approach for feature vector creation using data structure, tree is used. Multilevel Statistical Components are calculated and stored in Feature Vector organized as tree structure. It has been observed that feature vector for multilevel statistical components, proved better than the linear feature vector. As we increase the levels of the tree the performance of approach is also improved. Another important aspect about hierarchical data structure for Feature Vector is to enable image retrieval for parallel execution. Low level Color Feature effectively used in Spatial Domain for performance analysis. As a result of this approach feature vector dimensionality is achieved with improved discriminative power. Feature vector with Level 5 Tree provides better performance than n=1, n=2, n=3. Feature vector using Tree structure is cable for Parallel execution. It will be the future scope of this work.

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